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Nathalie Rabemalanto, Nathalie Pottier, Abla Mimi Edjossan-Sossou, Marc Vuillet

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1 **Research article: Household resilience to major slow kinetics floods: a prospective**  
2 **survey of the capacity to evacuate in high rise buildings in Paris**

3

4 **Nathalie Rabemalanto**<sup>1</sup>, **Nathalie Pottier**<sup>1,\*</sup>, **Abla Mimi Edjossan-Sossou**<sup>2,3</sup>, **Marc Vuillet**<sup>3</sup>

5 *Correspondence to : Nathalie Pottier (nathalie.pottier@uvsq.fr)*

6

7 <sup>1</sup> [nath.rabe@gmail.com](mailto:nath.rabe@gmail.com), [nathalie.pottier@uvsq.fr](mailto:nathalie.pottier@uvsq.fr). Center for Studies on Globalization, Conflicts,  
8 Territories and Vulnerabilities (EA4457 CEMOTEV-UVSQ), University of Versailles Saint Quentin-  
9 en-Yvelines - Paris-Saclay, France.

10 <sup>2</sup> [medjossan@gmail.com](mailto:medjossan@gmail.com) . University of Lorraine, CNRS, CREGU, GeoRessources laboratory, Nancy  
11 School of Mines, Campus Artem, CS 14234, Nancy Cedex, F-54042, France

12 <sup>3</sup> [marc.vuillet@eivp-paris.fr](mailto:marc.vuillet@eivp-paris.fr). Lab'urba, University Gustave Eiffel, Paris School of Urban Engineering,  
13 France

14

15 \* *Corresponding author:* [nathalie.pottier@uvsq.fr](mailto:nathalie.pottier@uvsq.fr)

16

17 **Abstract:** This article presents the results of a prospective survey of households living in the only high  
18 rise residential buildings of Paris, which are located in a flood zone. It questions the behavior of  
19 households likely to be subject to evacuation instructions in the event of a progressive flooding impacting  
20 the functioning of the technical networks and associated urban services. The survey received 523  
21 responses from 11 residential high-rise buildings located in the 15th district of Paris. It assessed the  
22 propensity of households to evacuate autonomously through three main factors: the capacity to self-  
23 evacuate, to self-host and to go to this temporary accommodation. The survey answers explicit requests  
24 for information by local authorities on inhabitants' capacities to self-evacuate and to self-host in order to  
25 support the formers' estimation of shelter requirements. The typology of evacuation capacities reveals  
26 that most of the respondents are partially dependent due to difficulties relating to re-accommodation  
27 issues. Furthermore, many people seems to have an incorrect perception of the public authorities'  
28 responsibilities. Information and warning systems could thus be improved, notably through a participative  
29 method.

30 **Keywords:** flood, evacuation, household resilience, prospective survey, Paris.

31



32

### 33 1. Introduction

34 A major flood of the Seine in Paris area would be a terrible challenge for crisis management services,  
35 inhabitants and the economy of affected territories, regardless of whether they are directly affected by  
36 flooding or not. According to the OECD (2014; 2018), a flood with a water level similar to the 100-year  
37 flood of 1910 would directly affect 1,000,000 people, with a flood duration of about one month. Nearly  
38 2,000,000 customers would be without electricity and nearly 5,000,000 without water. A very large number  
39 of people would therefore be heavily impacted without for all that suffering the direct impacts of the flood  
40 itself.

41 Various protection systems, including mobile or more conventional levees, have been designed to  
42 limit the extent of flooding (OECD, 2014). Nevertheless, their effects appear to be highly uncertain, mainly  
43 because of the unknowns of the risk of groundwater levels rising or the failure of a levee/cofferdam (Gache,  
44 2014). As a result of this, many technical networks and urban services would be shut down as a preventive  
45 measure. During the flood of May-June 2016, we witnessed the shutdown of the regional express train  
46 (RER C), which carries nearly 550,000 passengers a day, numerous power cuts and the evacuation of  
47 nearly 20,000 people. This flood, which was serious on a number of modest tributaries of the Seine (Loing,  
48 Yvette, Essonne in particular), remained a phenomenon of low amplitude within the Ile de France region,  
49 being considered as a 20-year flood in the city of Paris.

50 The risk of a major flooding of the River Seine would primarily raise the question of the fate of the  
51 830,000 people living inside the flood zone (OCDE 2014), compounded by the numerous people indirectly  
52 affected (power cuts, water and/or sanitation supply disruption, etc.). People who might have to evacuate  
53 should be cared for or be able to relocate for a period of days or even weeks, anticipating the kinetics of  
54 the flood. In this paper, we investigate the capacity of inhabitants living in the densely populated areas of  
55 the Paris urban area to self-evacuate and self-relocate in the event of a major flood of the River Seine.  
56 Kolen (2013) highlights the complexity of evacuation issues for large populations, stating that “*as the size  
57 of an evacuation increases, its complexity also increases*”. In the present study, not only is the population  
58 size large compared to the small area to be evacuated (cf. presentation of the survey area below), but the  
59 height of the buildings in question exacerbates the complexity of the evacuation process. When would the  
60 residents leave, knowing that the feeling of security in high-rise buildings might not favor the decision to  
61 evacuate? Which household profiles are likely to leave first? What are the factors which facilitate or  
62 handicap the autonomy of the households in the event of evacuation? These are just some of the issues that  
63 this case study raises.

64

65 Several researchers have studied the management of a major flood of the Seine in the Ile de France  
66 region. These studies examined the issue from a global standpoint (Reghezza, 2006) and from the point of  
67 view of the crisis management by national and regional services (November & Créton-Cazanave, 2017).



68 They also relate to the continued activity of network operators and urban services (Toubin *et al.*, 2015;  
69 Bocquentin *et al.*, 2020), the mobility and reassignment of employees who can no longer go to their  
70 workplaces (Lhomme *et al.*, 2019), social impacts (Fujiki & Renard, 2018) and household evacuation  
71 factors (Fujiki, 2017). Based on the cartographic exploitation of statistical indices and a bibliographical  
72 study, the work of Fujiki (2017) adopted a global approach to estimate the number of households that  
73 would need to be relocated for several major flood scenarios in the Ile de France region. This work  
74 represents a major breakthrough, making it possible to determine orders of magnitude for evacuation rates  
75 and evacuees requiring rehousing. Nevertheless, several additional pieces of data could usefully refine and  
76 supplement these results, in particular those relating to the inhabitants' perception (Navarro *et al.*, 2016)  
77 of the risk and the precautionary actions (Grothmann & Reusswig, 2006) as well as of the brakes and assets  
78 relating to self-evacuation and to self-hosting.

79

80 In this research, we propose to assess the household resilience in the face of an evacuation caused by  
81 a major flooding of the Seine, using a prospective survey. The aim is to try to identify the self-evacuation  
82 and self-relocation capacities of people living in a very high-density neighborhood, such as the  
83 Beaugrenelle high-rise flats located in the 15<sup>th</sup> district of Paris, in the face of a slow-motion flood scenario.  
84 We try to answer the following questions:

- 85 • What are the predominant factors influencing the target households' decision to evacuate?
- 86 • What is their perception of the risk?
- 87 • Do they have a means of travel and relocation?
- 88 • Are they able to continue their professional activity from their temporary place of residence?

89

90 The database used for this study is that of a prospective questionnaire conducted in 11 high-rise  
91 buildings in Paris. They are located in the 15<sup>th</sup> district, in an area along the banks of the River Seine. The  
92 data is provided by 523 respondents, representing 23% of the total number of residents who received the  
93 questionnaire. There are only a few residential high-rise buildings in Paris. The presence of this type of  
94 building in the "Front de Seine" zone has made it the most densely-populated area in the immediate  
95 vicinity. It is also more highly exposed to flooding, as demonstrated in the Flood Risk Prevention Plan  
96 (DULE, 2007). The survey explored the extent to which the residents are able to self-host and, to a slightly  
97 lesser extent, to self-evacuate. It also aimed to help determine the factors which lead to evacuation.

98 The remainder of this paper is structured as follows. First, the factors that can influence households'  
99 decision to evacuate in response to a natural disaster are presented. The equipment and methods used for  
100 the survey are then described together with an analysis of the results. The literature on evacuation decision-  
101 making justifies the content of the questionnaire. The results section will then illustrate the global trends  
102 relating to the characteristics of the sample, the constraints and factual information concerning the  
103 respondents' capacities and their perceptions of flood risk and evacuation. In large part, the results will  
104 highlight a typology corresponding to the propensity to evacuate. Finally, the respondents express their



105 expectations regarding the transmission of information and the evacuation process. These suggestions have  
106 been classified in order to help the authorities and everyone involved to define their strategies and actions  
107 when preparing the evacuation. The conclusion emphasizes the contributions of this study and highlights  
108 new avenues for reflection.  
109

## 110 **2. Factors influencing a household's decision to evacuate in the face of natural disaster**

111 The factors which lead households to decide whether or not to evacuate in situations of risk could be  
112 of an intrinsic and extrinsic nature. Among other things, these factors involve a household's capacity-  
113 related factors, risk perception, the structural and functional inhabitability of the place of residence, social  
114 influence and environmental factors facilitating or hindering the possibility of evacuating (Mileti, 1995;  
115 Dash & Gladwin, 2007; Lim *et al.*, 2016; Ahsan *et al.*, 2016).

116 Evidence exists of correlations between households' socio-demographic characteristics and their  
117 ability to leave or to stay in an area threatened by a hazard (Parker *et al.*, 2009). Generalizing these factors  
118 could nevertheless be problematic because the correlation can be negated or even reversed according to  
119 the case in question. Depending on the specific context of the area studied, the socio-demographic  
120 characteristics underlying a household's ability to evacuate may include, but are not limited to, gender  
121 (Mileti, 1995; Fraser *et al.*, 2014; Luatsep *et al.*, 2013), household size (Luatsep *et al.*, 2013; Smith &  
122 McCarty, 2009), the presence of vulnerable people such as children, senior citizens or persons with  
123 disabilities (Luatsep *et al.*, 2013; Lim *et al.*, 2016), ownership of and access to a vehicle (Wright &  
124 Johnston, 2010; Luatsep *et al.*, 2013), access to an available relocation place (Chang *et al.*, 2009), the  
125 presence of pets (Drabek, 2001; Heath *et al.*, 2001a, Solis *et al.*, 2010), etc. Because these factors vary  
126 from one household to another and the significance of their influence also varies depending on the context  
127 (Murray-Tuite & Wolshon, 2013), identifying households likely to evacuate can prove complex (Wright  
128 & Johnston, 2010).

129 Apart from socio-demographic characteristics, a household's intrinsic factors that can lead it to  
130 evacuate may include risk perception (Solis *et al.*, 2009): people can make an appropriate evacuation  
131 decision if they are aware of and understand their risk level (Piatyszek & Karagiannis, 2012). According  
132 to Jumadi *et al.* (2018), risk perception can be understood as the way households interpret the likelihood  
133 of threat; some households may consider themselves to be safe, thereby tending to think that evacuation is  
134 not necessary. A household's risk perception, and consequently its decision to leave or to stay, depends  
135 mainly on its previous experience of disasters (Dash & Gladwin, 2007) or its risk awareness (Whitehead  
136 *et al.*, 2000).

137 A household's behavior in the face of disasters also depends on certain extrinsic factors such as  
138 communication and information concerning the risk (De Jong & Helsloot, 2010). Households may decide  
139 to evacuate if they hear appropriate emergency information. Furthermore, in the face of natural disasters,  
140 people may decide to leave due to the inhabitability of their residence on the grounds of safety, utilities



141 shut-off and health (Wright & Johnston, 2010). Residents may indeed evacuate if they deem that the level  
142 of damage to their home caused by the hazard is so great that remaining inside could be unsafe or their  
143 well-being could also be affected. They might therefore leave their home when facing a disruption of  
144 lifelines provided by technical networks, including power outages, urban heating shut-offs or water supply  
145 system failures (Chatterjee & Mozumder, 2015). Furthermore, as social beings, a household's decision  
146 could be influenced by the society in which they live. They may take a decision based solely on their  
147 individual convictions and capacities or they might follow the example of their neighbors after seeing them  
148 evacuate (Lindell *et al.*, 2005; Jumadi *et al.*, 2018). Environmental cues may, for example, include hazard-  
149 related factors like sights, sounds or smells that indicate the onset of disaster, or the distance from the  
150 source of the hazard (Smith & McCarty, 2009; Lindell *et al.*, 2015). This type of cue also involves the  
151 “livability” of a household's neighborhood. The loss of normal operation of support systems and services  
152 (public transport, businesses, etc.) required to ensure a household's well-being and functioning may make  
153 it difficult to remain in their home (Wright & Johnston, 2010).

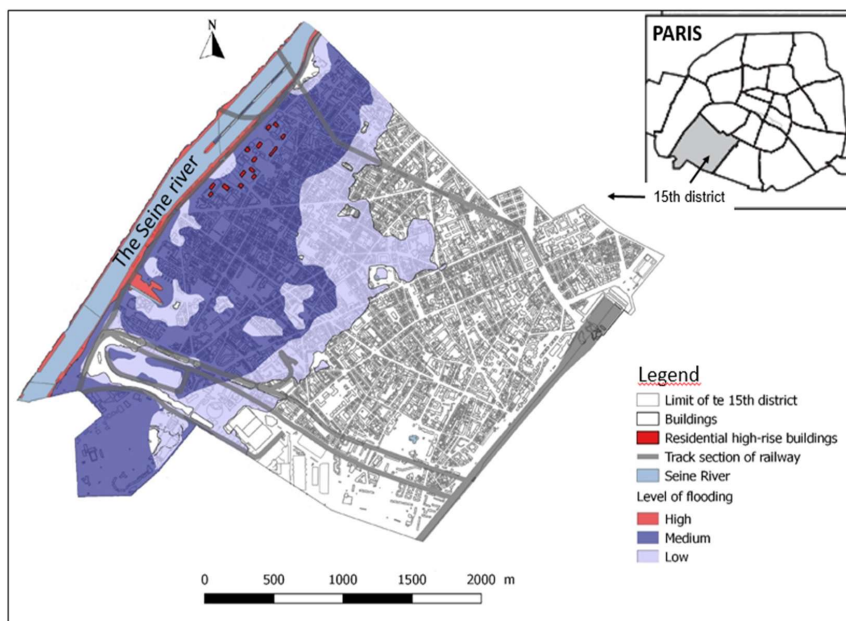
154 This study will mainly focus on intrinsic factors of the targeted households to gain an improved  
155 understanding of their capacity to self-evacuate, to self-host, and to move to a relocation place. This will  
156 help defining a typology of evacuation propensity that could be used to support the design of efficient  
157 evacuation strategies.

158

### 159 **3. Methodology: A prospective survey on household evacuation capacities**

#### 160 **3.1. The specificities of the study area include high-rise buildings exposed to the risk of flooding**

161 If we only consider the 20<sup>th</sup> and 21<sup>st</sup> centuries, the most extensive flooding of the Seine in Paris  
162 occurred in 1910. Despite the dams and levees that have been erected, the flood risk remains, even within  
163 the most densely populated neighborhoods of central Paris, as shown on the map (Fig. 1). This map shows  
164 the areas in the 15<sup>th</sup> district liable to flooding. In reality, there is little chance that the water would reach  
165 street level. However, water could penetrate underground car parks, mainly by dynamic capillary rise in  
166 the foundation walls. The actual issue in such an area is rather that technical network operators would have  
167 to implement preventive actions by disrupting the services. This raises the temporality issue of evacuation,  
168 as people would not see water in the streets or their buildings, but might have to leave because of the  
169 disrupted services.



170

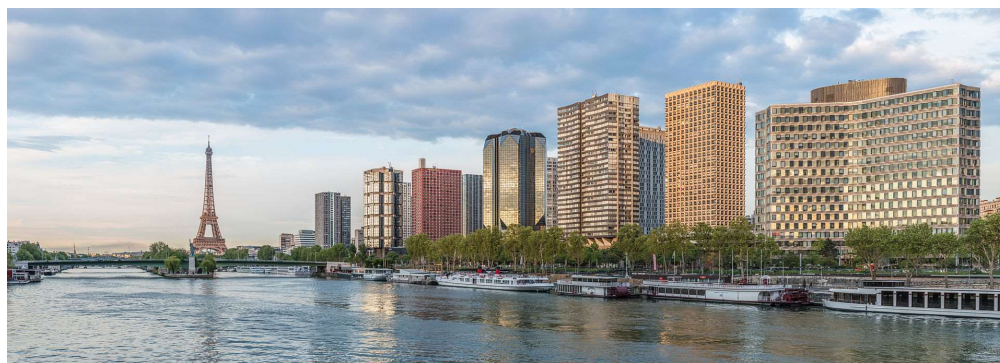
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**Fig. 1.** Flood risk zoning in the 15<sup>th</sup> district of Paris (Source: data from the Regional and Interdepartmental Office of Energy and the Environment, mapping by N. Rabemalanto and N. Pottier).



175

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179

**Fig.2.** The residential high rise buildings of the Front of the Seine river in the 15<sup>th</sup> district in Paris (source: [https://en.wikipedia.org/wiki/Front\\_de\\_Seine](https://en.wikipedia.org/wiki/Front_de_Seine)).





180 The 15<sup>th</sup> district was chosen for this study because it is widely exposed to the risk of flooding and is  
181 the most densely populated district in Paris (INSEE, 2016), due to the existence of residential high-rise  
182 buildings located exclusively in this territory along the Seine (fig.2). In 2015, the number of inhabitants in  
183 this district was nearly 234,000 while the density in the district has been quite stable since 1968 at around  
184 28,000 inhabitants/Km<sup>2</sup> compared to 21,000 for Paris as a whole (INSEE, 2016). Not only is this district  
185 the most densely populated because of the residential high-rise buildings, but the economic stakes in this  
186 area are also highly important. One of the biggest shopping malls in Paris is located here. Moreover, some  
187 of the high-rise buildings located in the “Front de Seine” area house companies or short- and mid-term-  
188 stay hotel residences. It is worth noting that this applied study examines the evacuation of the residential  
189 high-rise buildings only, rather than shopping mall visitors and hotel customers. This is because the  
190 residents are necessarily concerned with evacuation in the event of slow-kinetics flooding, and this would  
191 influence evacuation decision making.

192 Most of the residential high-rise buildings are built on an area 1 Km long (0.62 miles) and 200 m wide  
193 (218 yds). They have four levels of parking lots, two of which are at -2 and -1 in relation to street level.  
194 The car parks must therefore be evacuated even before the residents. This makes it more complex to  
195 coordinate the information concerning the evacuation of residents and cars. Another crucial piece of  
196 information is that the electrical systems of many of the buildings are located either at level -2 or -1. The  
197 buildings concerned are therefore vulnerable even before the Seine overflows its banks due to rising water  
198 in the basement. To limit damage, preventive power cuts inside these buildings can be implemented by  
199 operators several days before the water invades the streets. Evacuation is therefore mandatory since it  
200 involves the shutdown of the elevators and the height of the buildings makes it impossible to keep people  
201 inside. If some residents still choose to stay despite being advised to evacuate, mobility would be essential,  
202 especially for those living on upper floors.

203 Moreover, these people increase their exposure to other risks likely to cause domino effects which  
204 would amplify the disaster, such as the risk of fire and the impossibility for firefighters to intervene quickly  
205 to rescue those who have remained at home. In this case, slow kinetics flooding that does not cause death  
206 in the Paris region can turn into a deadly risk in high-rise buildings that have not been emptied of their  
207 inhabitants. Evacuation is therefore critical in the case of high-rise buildings in order to safeguard people’s  
208 lives and their access to all basic services. Several authors provide a clear explanation of what critical  
209 networks are and the different ways whereby they can be interdependent. Using tangible examples, they  
210 show how network disruptions can exacerbate crisis considerably (Toubin *et al.*, 2015; OECD, 2014). For  
211 all these reasons, preventive evacuation must be encouraged.

212

### 213 3.2. Questionnaire design

214 Data for this study was collected by means of a self-administered questionnaire (see in appendix). The  
215 questionnaire was entitled: “Are you prepared for the evacuation of the Front de Seine towers?”. It was





216 designed to gather data on household intentions regarding an autonomous evacuation (that is to evacuate  
217 or to remain at home) and the availability of evacuation destinations as well as modes of self-travel in the  
218 case of major flooding of the River Seine.

219 Even at the international level, there were only a few surveys on preparation for evacuation and  
220 decision making in the event of flooding with slow kinetics (Fujiki, 2017). Becerra *et al.* (2013) asserted,  
221 however, that when a hazard is weak, vulnerability is also weakened. Often, the existing surveys deal with  
222 the case of hurricanes, tsunamis or earthquakes (fast kinetics). For instance, many research works have  
223 made a significant contribution to the progress of knowledge about evacuation in the case of hurricanes  
224 (Huang *et al.* 2012; Dash & Gladwin, 2007). They found that the characteristics of the hazard were the  
225 main factor in determining evacuation decision-making (Whitehead *et al.*, 2000; Whitehead, 2005; Huang  
226 *et al.*, 2012).

227 As for the type of survey, at least since the 1950s, researchers have been interested in people's  
228 responses to risk (Baker, 1991; Thompson *et al.*, 2017), but most of the existing analyses on evacuation  
229 behavior focus on populations that have already experienced the situation (retrospective surveys). Some  
230 of the most well-known papers are those of Baker, 1991; Dash & Gladwin, 2007; Dow & Cutter, 2000;  
231 Gladwin *et al.*, 2001; Zaalberg *et al.*, 2009. Some more recent papers also used retrospective surveys,  
232 notably Demuth *et al.*, 2016; Lindell *et al.*, 2019; Wallace *et al.*, 2016. There are relatively few papers on  
233 prospective surveys examining the intention of households to evacuate following a disaster (Fraser *et al.*,  
234 2013; Lazo *et al.*, 2015). The challenge for this study in a Parisian district is thus its prospective  
235 characteristics. The prospective method is much more common in the fields of medicine, management,  
236 psychology, etc. Nevertheless, papers presenting evacuation modelling are also qualified as prospective  
237 studies (see for example Gladwin *et al.*, 2001) as they aim to predict what would happen based on the  
238 context and the assumptions. Instead of using random parameters as in the modelling process, this paper  
239 relies on respondents' declarations to provide an initial vision of people's perceptions, capacities and  
240 willingness to evacuate through a qualitative method.

241 The key questions for the analysis of evacuation conditions were inspired by decision models found  
242 in the literature. One of these is the Protective-Action Decision Model (PADM; Lindell & Perry, 1992,  
243 2012), which summarizes very well the different factors influencing the psychological processes of  
244 evacuation decision-making. It analyses the environmental and social cues, the information process and  
245 devices (sources, information channel access and preference, warning messages) and the receiver  
246 characteristics (Huang *et al.*, 2012).

247 In our survey, the questionnaire contains 23 questions with the following groups of variables (these  
248 groups of variables do not detail expressly every question asked in the questionnaire. The latter is available  
249 in the appendix). All questions asked were closed, except two questions on the respondents' expectations  
250 regarding the evacuation process and the information related to it.



- 251 • Respondents owning pets and difficulties in transporting them: pets might hinder the evacuation  
252 process mainly because their transportation might delay or make the departure more complex (Heath  
253 *et al.*, 2001b).
- 254 • The level of car park, if the respondent has one: the evacuation issue can vary according to the level  
255 at which the respondent's car is parked. First, those with a car parked at level -2 or -1 are more likely  
256 to be obliged to move it away if needed. Second, receiving an evacuation order for the car park might  
257 incite them to prepare themselves to evacuate soon as well.
- 258 • Knowledge about some basic information and the perceptions on the flood risk and evacuation  
259 process: this relationship between risk perception and the adoption of preventive behaviors is treated  
260 extensively in the literature (see, for example, Peretti-Watel, 2000; Becerra *et al.*, 2013).
- 261 • The main possible reason for evacuating: the respondent has to choose from the different reasons  
262 suggested (cf. questionnaire in *appendix*). The study might have revealed reasons linked to the fact  
263 that the respondents live in high-rise buildings. However, the impact of living in a high-rise building  
264 on their answers could not be verified as no direct questions were asked about this matter. A  
265 comparison with the reasons for evacuating identified in the literature in other contexts can  
266 nevertheless help to verify whether or not living in a high-rise building has any influence on the  
267 answers provided. Furthermore, this variable indicates the proportion of people who would be  
268 sensitive to evacuation advice and orders from public officials. Many studies have confirmed that the  
269 type of dwelling strongly affects household evacuation (Baker, 1991; Gladwin & Peacock, 1997;  
270 Horney *et al.*, 2010; Huang *et al.*, 2012; Lindell *et al.*, 2005; Whitehead, 2005; Wilmot & Mei, 2004;  
271 Zhang *et al.*, 2004). One might also consider that predicting the reason for evacuating automatically  
272 also makes it possible to predict the timing of people's departure. the former variable (the reason for  
273 evacuating) must be distinguished from the departure timing, according to past findings (Huang *et al.*,  
274 2012; Lindell *et al.*, 2005).
- 275 • The existence of a relocation destination and the possibility of continuing going to work or working  
276 at that place: law n° 2004-811 of August 13, 2004 on the Modernization of Civil Security recommends  
277 that people self-evacuate and self-host. This is why people are asked if they have a place to which  
278 they can relocate and if they can get there themselves. This law postulates that people should not count  
279 solely on public authorities in the event of an evacuation. It states that citizens must be responsible  
280 for their own safety. Accordingly, they must have a place to which they can relocate. Furthermore,  
281 the impossibility of continuing going to work or working at the relocation site can provide a reason  
282 not to evacuate. This question is therefore important when wanting to assess the proportion of people  
283 who would be willing to evacuate. Moreover, people are given the possibility in our questionnaire of  
284 specifying where their relocation site is. Sometimes, this makes them directly determine who would  
285 host them and whether they expect assistance from other people (public authorities, family, friends,  
286 etc.) or whether they would just not go to that site. This is what some authors call the effect of social



287 cues, meaning that during the evacuation decision-making process, people expect to receive help from  
288 others (Dash & Gladwin, 2007; Huang *et al.*, 2012).

289 • The expectations regarding the evacuation process and the information related to it: as the respondents  
290 could not express themselves broadly throughout the questionnaire, two questions allow them to do  
291 so here. They have the opportunity to write short texts, which might relate to some tangible actions  
292 they expect to be taken or how they would like to be better informed about the risk and evacuation  
293 process. They may also specify certain information they need in order to better prepare themselves  
294 for the hazard and for a potential evacuation.

295 • The characteristics of the respondent and their household: the socio-demographic variables are  
296 systematically analyzed when conducting a study about evacuation. Many authors (for instance Alou,  
297 2018; D’Ercole, 1991; Ruin *et al.*, 2008; Villa & Bélanger, 2012) have highlighted the fact that socio-  
298 demographic characteristics influence the way people face a hazard. Nevertheless, some authors (such  
299 as Baker, 1991; Dow & Cutter, 1998; Huang *et al.*, 2016) found in case studies that socio-demographic  
300 characteristics were not significant factors of the decision to evacuate. As Murray-Tuite & Wolshon  
301 (2013) stated, the significance of these characteristics in influencing evacuation decisions varies  
302 according to the context.

303

### 304 **3.3. Data collection and difficulties in accessing highly-protected buildings**

305 The printed questionnaires were distributed and collected over a 12-week period in spring and summer  
306 2019 by a postdoctoral fellow, helped on certain days by several others postdoctoral fellows and  
307 researchers. This period was chosen on practical grounds relating to the start of the survey. The  
308 particularity of this survey was that there could be no direct interaction between the investigator and the  
309 respondents. In fact, most of the buildings included luxury residences. Security measures and privacy  
310 considerations made it impossible to conduct a face-to-face survey. Consequently, the survey was based  
311 on voluntary sampling as the residents received the questionnaires and could choose whether or not to  
312 respond. The study area comprised 14 residential high-rise buildings. As the trustees of three of them did  
313 not allow the access to their buildings, the data were drawn from 11 buildings.

314 To prepare the survey, the lessors or trustees had to be informed and most of them helped organize  
315 the distribution process by asking the building managers to cooperate with the research project team. The  
316 term “manager” is used throughout this paper in order to facilitate reading, although some of them are  
317 concierges and do not have exactly the same functions as the building managers. One of two methods of  
318 distributing the questionnaire was adopted, depending on what best suited the building managers and the  
319 organization of the each building: some were left in the mailboxes while others were left at the building’s  
320 reception desk. Distribution via the mailboxes proved to be slightly more successful, as long as the building  
321 manager helped convince the residents to respond. Residents could leave the completed questionnaire at



322 the reception desk or return it by post. In one of the buildings, all respondents were obliged to return it by  
323 post in a pre-stamped envelope, as there was no reception desk in the building foyer.

324 With a total of 523 respondents and over 2,283 questionnaires distributed, the response rate was 23%.  
325 In light of the difficulty encountered in accessing these highly-protected buildings, the survey period (with  
326 many households already on vacation) and the fact that a lot of people in these buildings were foreigners  
327 often travelling for months at a time (according to the building managers), this rate is quite acceptable for  
328 voluntary participation. Only three buildings displayed a response rate of less than 20%. Accordingly,  
329 almost one in four people per building answered the questionnaire. However, voluntary response means  
330 that sampling might be biased as only those people already aware of or curious about the topic may have  
331 responded. It is important to take this into account because the survey itself concerns the willingness to  
332 evacuate. If a person were not willing to evacuate and thus refused to answer the questionnaire, this would  
333 represent a considerable loss of information. The present results nevertheless remain valid even though  
334 they do not necessarily represent everyone's situation and opinion. In comparison, the following response  
335 rates are those of evacuation surveys with people who have actually experienced a catastrophe (cited by  
336 Huang *et al.*, 2012): 25.7% for Hurricane Bret, 24.6% for Texas coastal evacuation expectations, 33.5%  
337 for Hurricane Katrina, and 35.6% for Hurricane Rita. The present study, however, concerns a hypothetical  
338 event that has not been experienced. People might be more willing to respond to a survey about their actual  
339 experiences, so this 23% rate for a prospective survey is relatively acceptable.

340

#### 341 ***3.4. Analysis method: typology of households according to the level of autonomy in an evacuation*** 342 ***situation***

343 The main results will be provided in the form of a households's typology expressing their level of  
344 autonomy in the event of evacuation. The following five criteria are used to produce it:

- 345 • C1: intention to evacuate relying on stated reasons, bearing in mind that some people will not  
346 evacuate, regardless of these reasons (Fraser *et al.*, 2013). This criterion takes a value of (1) if a  
347 household stated one or more reasons that may push them to evacuate and (0) if a household was not  
348 willing to evacuate;
- 349 • C2: the availability of a self-host destination (Chang *et al.*, 2009). This criterion was coded (1) if a  
350 household had one or more relocation place(s) and (0) otherwise;
- 351 • C3: the capacity to move from the area by their own means of transport (Luathep *et al.*, 2013). A  
352 value of (1) was assigned if respondents stated that they would leave their place of residence by private  
353 car and (0) if they stated they would use other means (public transport, close relative's car, means of  
354 transport provided by public authorities or thanks to solidarity, etc.) or did not know;
- 355 • C4: access to the workplace or possibility of working from their evacuation destination, as work  
356 obligations could reduce the likelihood of evacuation (Mesa-Arango *et al.*, 2013). Respondents who



357 answered that they would be able to keep going to work or keep working at their relocation place were  
358 coded (1) and (0) if they would not;

359 • C5: the presence of vulnerable people in the household (Lim *et al.*, 2016). This criterion took a value  
360 of (1) for a household with no particular constraints relating to physical capacities and (0) if the  
361 household had one or more particular condition.

362 These criteria were chosen because they are the most reliable ones which best reflect the tangible (and  
363 therefore observable) factors of evacuation. They also correspond to significant factors frequently  
364 mentioned in the literature.

365 The definition of the typology broken down into two levels. The first level contains 4 types:

- 366 • Type 1 (T1) => totally autonomous: all above criteria with the value “(1)”;
- 367 • Type 2 (T2) => partially dependent: declared one or more reasons that could push them to evacuate  
368 (C1=1) and at least one other criterion with the value “(0)” above;
- 369 • Type 3(T3) => totally dependent: declared one or many reasons that could push them to evacuate  
370 (C1=1) and all other criteria with the value “(0)” above;
- 371 • Type 4 (T4) => not willing to evacuate: declared that they were not willing to evacuate (C1=0).

372 The second level consists of splitting type 2 (T2) into types “2a, 2b, 2c and 2d” according to the  
373 criteria that make the respondent partially dependent in the event of evacuation

- 374 • Type 1 (T1) => totally autonomous: all criteria above with the value “(1)”;
- 375 • Type 2a (T2a) => declared one or more reasons that could push them to evacuate (C1=1) and partially  
376 dependent with regard to the relocation place (C2=0) and/or the means of transport to get there (C3=0)  
377 only;
- 378 • Type 2b (T2b) => declared one or more reasons that could push them to evacuate (C1=1) and partially  
379 dependent with regard to the possibility of continuing going to work or continuing working at their  
380 relocation place (C4=0) only;
- 381 • Type 2c (T2c) => declared one or more reasons that could push them to evacuate (C1=1) and partially  
382 dependent with regard to constraints relating to physical capacities (C5=0) only;
- 383 • Type 2d (T2d) => declared one or more reasons that could push them to evacuate (C1=1) and partially  
384 dependent with regard to a combination of two criteria (C2=0 and/or C3=0 and/or C4=0 and/or C5=0)  
385 apart from the combination of “having a relocation place (C2=1) and a private means of transport to  
386 get there (C3=1);
- 387 • Type 3(T3) => totally dependent: declared one or more reasons that could push them to evacuate  
388 (C1=1) and all other criteria with a value of “(0)” above;
- 389 • Type 4 (T4) => not willing to evacuate: declared that they were not to be willing to evacuate (C1=0).

390 To simplify the explanation, the following classification tree (see fig.3) presents the combination of  
391 criteria for each group in the second level of the typology.



392 The descriptive statistics are then used to describe each type. The aim is to highlight any existing  
393 criteria common to all the types with regard to socio-demographic characteristics together with the factors  
394 for against evacuation. Finally, the results are completed by a brief analysis of the residents' expectations  
395 regarding the preparation of the evacuation process and the related information (cf. section 4.3).  
396

### 397 **3.5. Sample profile of the respondents**

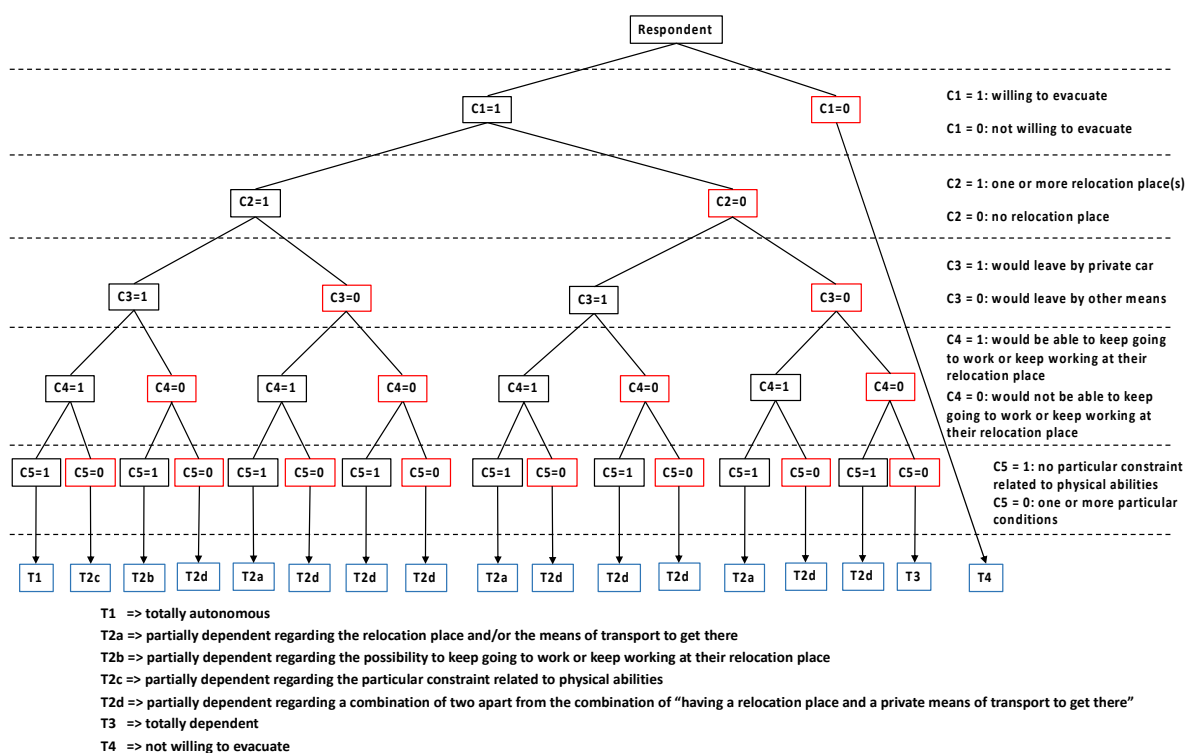
398 The sample structure shown in Table 1 reflects the highly specific character of the inhabitants of the  
399 "Front de Seine" towers in the 15<sup>th</sup> district of Paris with a high average age (84% are over 45 years old,  
400 48% over 65), households composed mostly of one or two people (82.6%), a small majority of retired or  
401 inactive residents (51.5%) and respondents having lived in this neighborhood for an average of 16 years.  
402 Few of the respondents have a pet (14%) and a majority of households own a car (51.8%), which is  
403 explained both by a higher standard of living than the neighborhood average (according to information  
404 collected from the building managers who know their residents very well) and by the existence of a  
405 dedicated car park (quite rare in Paris).

406 The slight over-representation (48%) of people over the age of 65 in our sample (according to the  
407 building managers) is explained by their greater availability, their interest in security issues and an  
408 awareness of being more vulnerable or dependent on their surroundings if evacuation is necessary. Their  
409 vulnerability is exacerbated in the event of power supply failures that would oblige them to leave the multi-  
410 floor residential buildings without the benefit of an elevator. Moreover, other categories of people might  
411 not only feel unconcerned, but they might also be wrongly informed about the topic. Arlikatti *et al.* (2006)  
412 and Zhang *et al.* (2004) stated that risk-area maps do not necessarily allow some people to understand that  
413 an evacuation warning applies to them and therefore consider that they are not particularly concerned by  
414 the evacuation survey.

415 The high proportion of respondents living alone or in a couple (49% and 33% respectively) reflects  
416 the trend in Paris as a whole and in the 15<sup>th</sup> district, where 51% of the population live alone (INSEE, 2019).

417 Among the respondents, 48% are over 65, and 4% have reduced mobility – characteristics that must  
418 be taken into account in the event of an evacuation without elevator. This vulnerable population is clearly  
419 identified by the building managers as they know they have to prioritize them. This raises the question of  
420 coordinating the evacuation of the different categories of people in the building by the building manager(s).  
421 It also raises the question of their training, in so far as they claim that they have not received specific  
422 instructions regarding this type of situation.

423  
424



425

426

Fig. 3. Household typology according to evacuation capacities (second level of typology)

427





**Table 1.** Respondent’s characteristics

Variable	Sample
<b><i>Respondents’ demographics</i></b>	
<b>Gender</b>	% (n= 522 )
	Female / Male
	57.1% (298) / 42.9% (224)
<b>Age group</b>	% (n = 517)
under 25	0.9 (5)
25 to 45	15 (78)
45 to 65	35.8 (185)
Over 65	48 (249)
<b>Number of people in the household</b>	Study area % (n=512)
1	49.4 (253)
2	33.2 (170)
3	9 (46)
4	6.8 (35)
5 or more	1.5 (8)
3 or more (total 3-4-5)	17.3 (89)
<b>Occupation</b>	% (n=520)
Active	48.4 (252)
Retired	45.2 (235)
Inactive	1.7 (9)
Active and retired	4.6 (24)
<b><i>Other characteristics</i></b>	
<b>Floor</b>	% (n=514)
0 to 8	17.3 (89)
9 to 16	34.6 (178)
17 to 24	26.7 (137)
25 to 33	21.4 (110)
<b>Year of installation</b>	% (n=510)
1970-1980	17.4 (89)
1981-1990	15.5 (79)
1991-2000	17 (87)
2001-2010	20 (102)
2011-2019	30 (153)
<b>Own an animal</b>	% (n=523)
No	87.1 (456)
Yes	12.81 (67)



Own a car	% (n=523)
Yes	51.8 (271)
No	48.2 (252)

429

## 430 4. Results and discussion

### 431 4.1. The main constraints on the respondents

432 Globally speaking, the majority of residents are not subject to tangible constraints in the event of  
433 evacuation. A little over half the households in our sample (52%) own a car and could be autonomous  
434 during an evacuation. Some 32% declared that they counted on the public authorities to provide them with  
435 a relocation place and 7% stated that they did not know where to go. This will be discussed below.  
436 Generally speaking, the households own no pets, but those who own at least one (13%) seem to be attached  
437 to it. When asked about any particularities of the household to be taken into account in the event of  
438 evacuation, some specify that they have a pet and indicate the number of pets living there. This type of  
439 person might not be willing to evacuate.

440 The analysis of responses in terms of expectations and information needs in the event of the need for  
441 evacuation reveals high expectations in terms of support from the public authorities.

442 Most residents seem to have a correct perception of the flood risk and evacuation procedures in their  
443 area, or at least to be aware of the issue. Only 15% think that their area has never been flooded. As  
444 mentioned above, a huge part of the Parisian territory, including a major part of the 15<sup>th</sup> district, was  
445 completely flooded in 1910. Some 64% of respondents know that their area might still be flooded despite  
446 all the infrastructures built to control rising waters. This result shows that residents are well aware of the  
447 limitations of the structural measures. This can be seen as evidence of progress in flood risk awareness led  
448 by the Seine-Normandy basin stakeholders. On the other hand, they have distorted ideas relating to specific  
449 but essential technical points. This affects their perception of the magnitude of the consequences of a major  
450 flood, which would necessitate preventive cuts of urban technical networks. Some 54% think that their  
451 building has a generator that will guarantee their electricity supply for at least 4-5 days. However, the  
452 generators have only 24 to 48 hours' autonomy and while they are present in every building, most of them  
453 are located underground and are therefore vulnerable to groundwater.

454 The last important result relating to the level of knowledge about evacuations is that 46% of the  
455 respondents are aware that the public authorities cannot host all residents of the high-rise buildings. Some  
456 45% declared that they did not know whether the public authorities have this capacity or not. This could  
457 be linked to a statement made by one respondent, essentially claiming that, "*The public authorities*  
458 *objectively might have the means to host everyone but it might not be their priority, or they might have*  
459 *their own reason not to be willing to do so*". Debating whether the public authorities should indeed host  
460 everyone falls outside the scope of this study. It actually raises a much broader and hotly debated issue of  
461 public policies and the sharing of responsibilities in such a situation (Godfrin *et al.*, 2002). In order to



462 provide analyses that can be used more directly, we prefer to acknowledge the existence of law n° 2004-811  
463 on the modernization of civil security. It would therefore be more relevant to identify the conditions in  
464 which the evacuation process could be efficient.

465 People's perceptions vary considerably as far as this law is concerned. According to the present study  
466 results, 52% agree while 39% disagree and the remaining 9% have no opinion on the matter. However,  
467 such perceptions do not systematically reflect the same meaning. People subject to no constraints, for  
468 instance, sometimes disagree with this law not because of their own situation but for the sake of vulnerable  
469 individuals who need assistance. Nonetheless, such a perception might not exactly reflect their actual  
470 opinion. In reality, when answering the question, people might have thought that this law applies to persons  
471 with reduced mobility as well, but this is not the case. The results (people's opinions) would ideally require  
472 further explanation, especially in the case of those who declared that they disagree with law n° 2004-811.  
473 In the end, this global trend in the level of knowledge about the flood risk and evacuation procedures is  
474 rather reassuring because one of our hypotheses was that the residents have mistaken perceptions about  
475 the flood risk. In light of these global perception trends, many respondents have what would appear to be  
476 the correct perception of the risk and the evacuation conditions.

477 As for the evacuation process, 60% of the respondents expect to receive evacuation advice from the  
478 public officials between 24 and 48 hours before the water reaches their area. This means that a lot of people  
479 count on the capacity of the public authorities to anticipate the event, whereas the matter is actually more  
480 complex than that. In fact, at the end of the survey, some respondents specified that evacuation should be  
481 recommended only if this is genuinely necessary. The problem here is that there is no guarantee that  
482 advising residents to evacuate 24 to 48 hours beforehand would be relevant. Naturally, anyone involved is  
483 faced with uncertainty whenever they are in a context of natural hazards. More precisely, the predicted  
484 flooding and evacuation scenarios can never be a hundred percent reliable. The public authorities often  
485 forget to take this element of uncertainty into account in the crisis management process. The contribution  
486 of Kolen (2013) is important in light of the need to implement effective safety strategies despite the  
487 uncertain nature of flood risks.

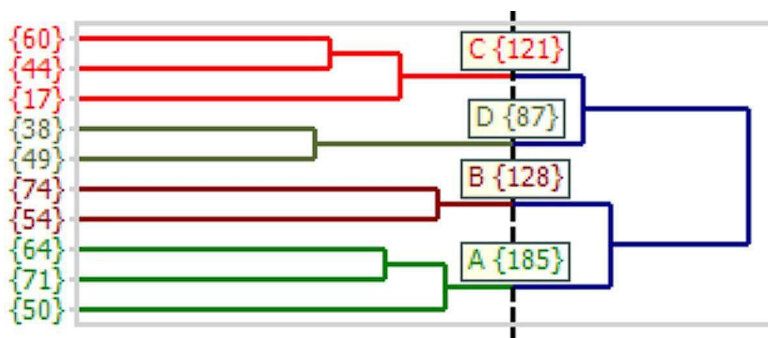
488 The perception of the timing during an evacuation process might help in anticipating people's  
489 behavior. Among those who own a car, 43% declared that if they received an evacuation notification, they  
490 would wait at home and see how critical the situation got. A further 28% would leave home within 24  
491 hours and only 12% would leave immediately. Most people would therefore remain at home and judge for  
492 themselves if they need to leave. The problem ascertained by Alou (2018) is that people sometimes have  
493 difficulty in obtaining the right information about a situation that would directly affect them, thereby  
494 causing them to evacuate too late. This statement is accurate in the case of high-rise buildings residents.  
495 The information gleaned from the media affects them differently in comparison to residents of smaller  
496 buildings. The point at which their electrical generator is flooded might be different from the time other  
497 buildings are flooded at some level (underground or not). This means that they have to be informed more  
498 directly via the building managers and the managers of the underground parts.



499 The survey probed the Parisians on the reasons which would decide them to leave their tower for  
 500 several weeks in a situation of major flood of the Seine (see question 11 on the appendix). Among the 10  
 501 reasons proposed, three main reasons to evacuate were reported by the residents: evacuation advice from  
 502 the public authorities (71%), the degradation of everyday commodities inside and outside their home (52%)  
 503 and the existence of a private or a public relocation place (50%). The first reason reflects the same findings  
 504 as those obtained by Baker (1991), Dash & Gladwin (2007) and Kreibich *et al.* (2017): official warnings  
 505 are important factors of evacuation decisions. Of course, this is underpinned by a certain number of  
 506 conditions, notably the communication channel used and the clarity of the message, as reported by Baker  
 507 (1991), Paul & Dutt (2010), Parker (2017) and Gissing *et al.* (2019). The two other main reasons (i.e.  
 508 degradation of everyday commodities inside and outside their home and the existence of a private or a  
 509 public relocation place) have a greater direct impact on people than other reasons mentioned in the  
 510 questionnaire such as seeing the neighbors leave, information in the media, etc. As is commonly found,  
 511 expected personal impacts strongly incite people to protect themselves and better anticipate an evacuation  
 512 (Fritzpatrick & Mileti, 1991; Huang *et al.*, 2012; Lindell & Perry, 1992).

513 To go further in the analysis, an ascending hierarchical classification performed on the ten evacuation  
 514 reasons (variables) with the Sphinx iQ2 software (fig.4.a and fig.4.b). It highlights the groups of  
 515 explanatory reasons for the propensity to evacuate according to households profiles.

516



517

518 Fig.4.a. Dendrogram of the question 11 (in appendix) with 521 complete observations on a total of  
 519 523.

A (185)	+ q11i, q11g - q11e, q11d, q11j, q11c, q11a
B (128)	+ q11e, q11b, q11f, q11h - q11j, q11d, q11a
C (121)	+ q11j, q11a - q11h, q11g, q11i, q11f, q11c, q11d
D (87)	+ q11c, q11d - q11b, q11i, q11g

520  
 521  
 522

Fig.4.b. Characterization of classes of respondents according to 10 evacuation reasons (variables q11a to q11j).



523 The dendrogram in fig.4.a allows to identify four groups of respondents according to the classification  
524 of answers group they gave. The characterization of classes of respondents (fig.4.b) shows for the variables  
525 in green, the mean values of the class are significantly higher than those of the rest of the sample. The two  
526 main decisive reasons for evacuating are knowing that your accommodation is in a secure area and having  
527 a private or a public relocation place (group A: 185 respondents on fig.4.a). The analysis confirms too that  
528 people are awaiting public or mediatic and precise information and information on the consequences of a  
529 refusal to evacuate before taking their decision (group B, fig.4.b).  
530

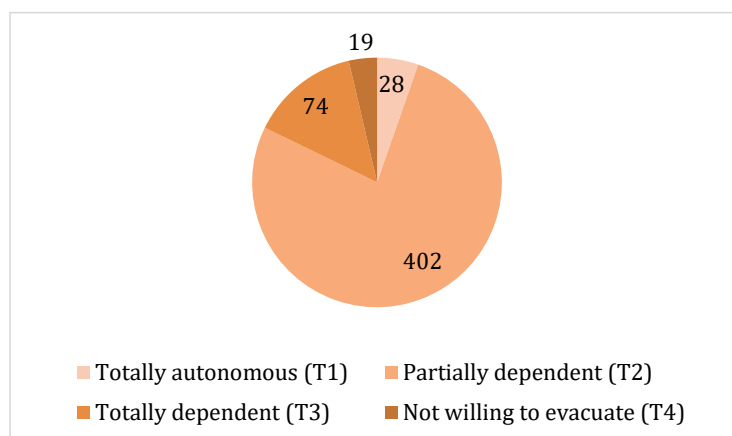
#### 531 **4.2. Typology of households according to evacuation capacities**

532 The first level of typology, which distinguishes autonomous households from others, shows that most  
533 respondents (77%) are partially dependent in the event of evacuation (fig.5). We named this group T2 on  
534 fig.2. This initial information is not surprising. It leads to further analyses in order to better understand the  
535 factors that make this group partially dependent and to anticipate the actions to be taken in order to  
536 guarantee security when evacuating. That is the object of the second level of typology, explained below  
537 (fig.3). Among those people who are totally dependent (group T3, accounting for 14%), there are many  
538 old people who may be somewhat socially isolated. They may have neither a relocation place nor a private  
539 means of transport to get there. These old people are automatically classified in group T3 as they display  
540 all the criteria of a lack of autonomy. As for the few respondents in the group T4 who declared that they  
541 would not to be willing to evacuate, such a statement has to be taken with some caution. It is to be included  
542 in the typology, although it is not a directly observable variable because it is a crucial information.  
543 Nevertheless, a number of building managers stated that when they attempted to initiate an evacuation  
544 exercise, people were definitely not reactive. The reasons for this could not be formally verified, but it may  
545 mean that the residents are not convinced of the necessity for such an exercise. If so, they might also not  
546 be convinced that one day they could actually be asked to evacuate. This small proportion of T4 could  
547 therefore be misleading. In a real context of flooding and evacuation advice, the different actors involved  
548 expect that a larger proportion of people would not be willing to evacuate. Further explanations for this  
549 will be provided later in this paper.

550 The second level of the typology splits T2 (partially dependent) into T2a, T2b, T2c, and T2d (fig.3).  
551 Fig.6 reveals that many people are partially dependent, mainly because they do not have a relocation place  
552 and/or a private means of transport to use (T2a accounting for 55%). Hence, the issue of a relocation place  
553 and means of transport has to be seriously considered. Furthermore, the global tendencies described above  
554 reveal that knowing where to go in the event of an evacuation is one of the three main reasons that could  
555 incite people to evacuate. This also reflects the fact that most people may actually rely on public authorities  
556 with regard to these two elements (relocation place and means of transport). Consequently, the public  
557 authorities might have to anticipate a double phenomenon in the event of evacuation: (i) the first level of  
558 typology reveals a very small number of people not willing to evacuate, but many others might also not

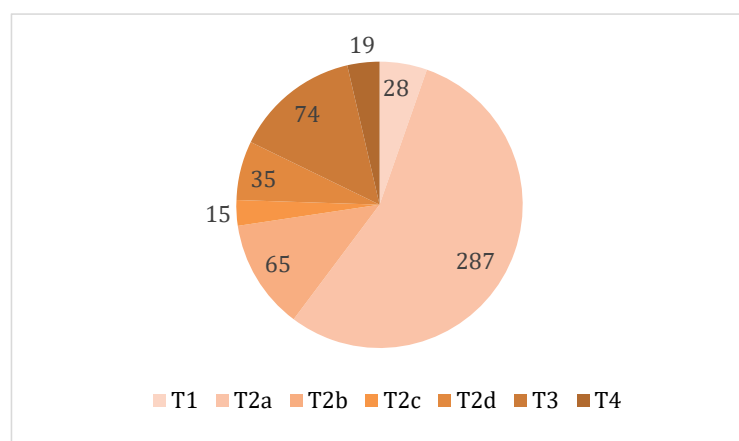


559 evacuate if they do not know where to go or how to get there; and (ii) for those who are willing to evacuate,  
 560 most of them count on the assistance of the public authorities. Even the proportion of T2b (12%) confirms  
 561 that the relocation place and mobility are key issues because people in this category are not certain to be  
 562 able to continue going to work or working at their relocation place. This break-down of T2 helps us  
 563 understand why the debate about law n° 2004-811 is so sensitive and often beset by controversy, given  
 564 that one of the critical issues is the relocation process. The analysis of access to relocation places could  
 565 therefore be refined through more formal models and more detailed qualitative interviews.



566

567 **Fig.5.** Typology with respect to the respondents' evacuation capacities (first level of typology)



568

569 **Fig.6.** Typology with respect to the respondents' evacuation capacities with detailed types of  
 570 partially-dependent people (second level of typology)

571 These arguments lead to a more detailed analysis of who belongs to which type, with three main  
 572 descriptive categories:



- 573 • A comparison of the 7 types considering the socio-demographic variables of age and gender. Age  
574 inevitably needs to be analyzed because the relationship between old age, isolation and mobility has  
575 already played an important role in this study. Gender will also be analyzed here because at this stage,  
576 it may open up avenues for more interesting reflection. It was not mentioned earlier in this study  
577 because even though some authors, such as Whitehead *et al.* (2000), found that women were more  
578 likely to evacuate, our hypothesis is that gender has no effect on evacuation decisions and capacities,  
579 echoing the results of Baker (1991), Dow & Cutter (1998) and Huang *et al.* (2016);
- 580 • A comparison of the 7 types considering the perception of law n° 2004-811. This perception can be  
581 better interpreted now that we have divided the respondents into seven types. It is mostly important  
582 to understand whether certain types tend to hold the same opinion on this law. Furthermore, such a  
583 comparison would help distinguish those who are subject to physical constraints and might have stated  
584 that they disagree with this law. As explained above, such a declaration might actually be biased  
585 because self-evacuation and self-hosting, as stated in law n° 2004-811, does not apply to people with  
586 reduced mobility;
- 587 • A comparison of the 7 types considering two variables that could add significantly more capacities or  
588 constraints to the evacuation process, namely possession of a vehicle and the level of the floor where  
589 the respondent lives.

590 With respect to type and age group, the distribution shows that a large majority (59%) of the  
591 individuals totally autonomous (category T1) are aged between 45 and 65, and 30% are over 65. For those  
592 who are partially dependent regarding the relocation place and/or the means of transport to get there (T2a),  
593 the proportions are quite similar between the 45-65 group (43%) and the over-65s (39%). Moreover, the  
594 older the residents are, the less likely they are to be able to continue going to work or continue working at  
595 the relocation place. Among those who are totally dependent (T3), 66% are over 65 years old. In T2c  
596 (partially dependent regarding the particular constraint related to physical abilities), half are relatively  
597 young, aged between 25 and 45. This is normal because the older residents would display the numerous  
598 criteria underpinning a lack of autonomy, which is why they would belong to categories other than T2c.  
599 These results show that type and age group are often linked to one another.

600 The classification according to gender is standard, with 55% women, 40% men and 5% indicating  
601 both genders because they might have completed the questionnaire together. Women are predominant in  
602 T2a (60%), T3 totally dependent (63%) and T4 not willing to evacuate (58%). In contrast to our hypothesis,  
603 they might therefore be more vulnerable than men. Incidentally, while they might be more vulnerable, they  
604 are not more likely to evacuate, again in contrast to our hypothesis. In such a modern society, it is difficult  
605 to provide any explanation for such a trend. Rather than reusing these results, it would better to conduct a  
606 new survey or interviews to control for different possible factors of a socio-psychological, physical or  
607 other nature.

608 The result of classification with respect to type and opinions concerning law n° 2004-811 on the  
609 modernization of civil security is very coherent. Respondents displaying negative opinions (38% in total),





610 meaning that they do not approve the law, are clearly predominant in group T3 (totally dependent, 40%)  
611 and T4 (not willing to evacuate, 42%). On the other hand, those who agree with the law are predominant  
612 in all other types. In T2a, there is very little different between the proportion of those who agree with the  
613 law and the share of those who do not. Once again, this reflects the different situations of the residents, as  
614 far as evacuation is concerned, who do not have the same opinion about the law within their own group.  
615 This opinion should be clarified in further studies.

616 Furthermore, when people do not own a vehicle (48% in total), they mostly whether belong to T2a  
617 (65%) or T3 (totally dependent, 69%). Again, such proportions are coherent. As the proportions of those  
618 who do not own a vehicle in these two types are significant, this distribution effect gives the impression  
619 that only those who own a vehicle belong to the five other types, which does not necessarily make sense.  
620 Incidentally, 93% of those who own a vehicle belong to T1 (totally autonomous). However, owing a  
621 vehicle does not guarantee total autonomy. Independent of owing a vehicle, autonomy also depends on the  
622 priority criteria defined in our methodology (fig.3).

623 Last, the level of the floor is quite random for most types except, in two cases. In T1, 46% live above  
624 the 24<sup>th</sup> floor, which means that the most autonomous people tend to choose to live on the upper floors. On  
625 the contrary, 16 of the 19 people in T4 (not willing to evacuate) live below the 17<sup>th</sup> floor. They probably  
626 focused on the issue of the elevator, thinking that it would not affect them if it stopped working because  
627 they felt able to cope on their own. This data could prove useful in improving information for residents in  
628 the event of evacuation and to dispel misconceptions.

#### 629 ***4.3. Respondents' expectations regarding evacuation information and preparedness***

##### 630 **4.3.1. Information as a priority issue**

631 Here we present a brief analysis of the residents' expectations regarding preparation of the evacuation  
632 process and the associated information. To this end, a word tree was generated from the text contained in  
633 the 521 responses to the open-ended question 17: "what would you like to be done so that you would be  
634 better prepared in case you need to leave?" (see questionnaire in Appendix) (fig.7).

635 This text is transformed into a visual tool where the words are arranged in a tree-like branching  
636 structure which reveal recurrent ones and indicates the strength of their semantic proximity in the text. The  
637 word tree visualization method consists of counting the frequencies or repetitions of quoted words for  
638 calculating their semantic proximity (Wattenberg & Viégas, 2008). For this, we used the open source  
639 online application "[www.treecloud.org](http://www.treecloud.org)" (where the algorithms were implemented by Gambette & Véronis,  
640 2010). The figure which one obtains consists of branches of words or "edges". These edges are all the  
641 longer as the word classes are the most significant (close to each other, well separated from the rest on the  
642 figure). This visualization tip improves readability compared to a simple word cloud. The advantage of the  
643 tree view is also to benefit from a better amount of information (represented by a number of groups or  
644 "bags" linear nested words) and better quality of information (considering global information by matching



645 words in the tree). The coloring of the words guides the reading according to different possible criteria  
646 (their frequency of use in the responses, their chronology in a speech, etc.).

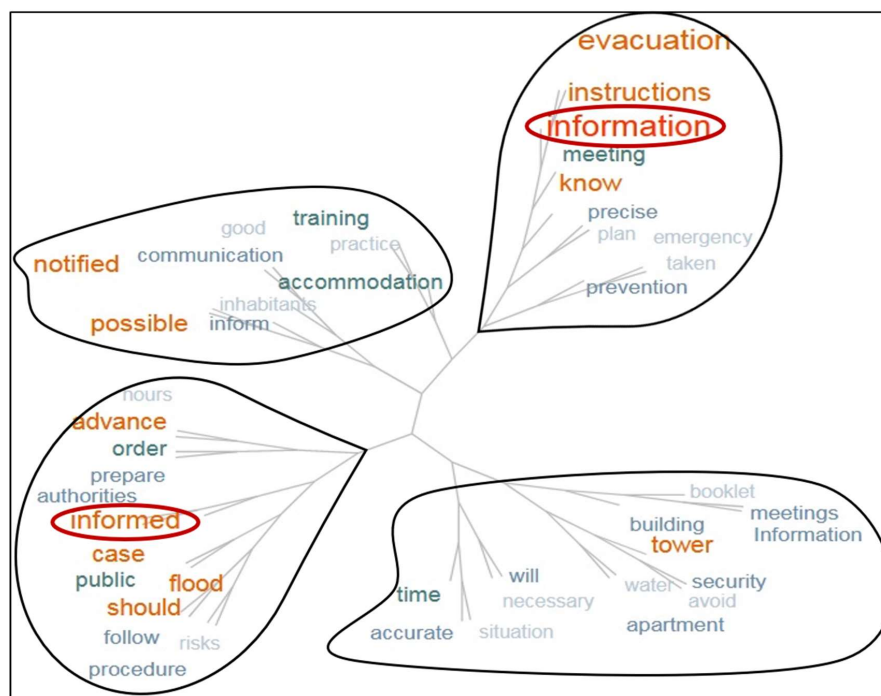
647

648 Here in the fig.7, the font coloring associated with the words is linked to their frequency (from light  
649 blue for the little cited word to red and bold for those cited several times). When comparing the branches  
650 of the tree built from the most frequent words used in the respondents' opinions gathered from question  
651 17, these following conclusions arise. The respondents most often cite the word "information", which  
652 appears in red in the longer branch of the tree, upper right on the figure. In this branch of words, the word  
653 "information" is associated in descending order with the word "evacuation", then "instruction" and  
654 "know". In the symmetric branch (on the bottom left of the figure), the words "informed", "case",  
655 "advance" are among the five words which have the highest frequency; in addition to "flood" and "should".  
656 Thus, the idea of being well informed, especially on the practical modalities on "evacuation", is the priority  
657 for the respondents who live in the Seine front towers.

658 In fact, people very frequently ask to be informed about numerous details regarding the evacuation  
659 process. Instead, they could have requested some form of help, for instance, but very few people thought  
660 of it. Together with information, people wish to receive clear instructions in good time so they can prepare.  
661 Some mentioned that receiving instructions at an early juncture would help them prepare their relocation  
662 place. As Dash & Gladwin (2007) explained, "warning is an integral component of evacuation decision  
663 making". Others replied that they will follow the information provided by the authorities. This echoes our  
664 previous finding relating to the importance people give to instructions and evacuation advice from the  
665 public authorities. Some respondents also pointed out the need for an evacuation drill, with some of them  
666 who even specified the expected frequency of such a drill; for example, once or twice a year. The question  
667 of communication is also addressed by the respondents through the recurrence of the words  
668 "communication" and "meetings". They would like to have regular meetings about the situation and to be  
669 given pamphlets presenting the risks and safety measures. In reality, people might not use these means of  
670 communication (pamphlets, Internet and others), but sharing them might improve peoples' knowledge and  
671 consciousness, if only to a small degree.

672

673



674

675 **Fig. 7.** Word tree of the respondents' expectations in order to be better prepared for an evacuation

676 **4.3.2. Implications on information dissemination practices**

677 The importance of information is clearly described by Colbeau-Justin & de Vanssay (2001) through  
678 their case study conducted in the *département* of Somme in France. Due to the lack of information and  
679 formal and sustainable information channels both before and after the flooding, there were rumors about  
680 and denial of the flood risk. Becerra *et al.* (2013) mention examples where such a phenomenon led the  
681 authorities to introduce alarm systems. Such an experience shows that information is crucial and because  
682 it is requested by the residents themselves, it is a form of responsibility that they assume, as it helps in  
683 preparing themselves for a "crisis".

684 In our case study, rumors about and denial of the flood risk are not the only issues as far as the  
685 knowledge of the people is concerned. In fact, the textual answers reflect a very approximate knowledge  
686 of the person responsible for one or other action – for example: who sets the alarm? Some think that the  
687 prefecture has to deal with all tasks related to evacuation. Generally, the distribution of the public officers'  
688 functions is clearly explained on internet. People therefore need to be better informed through more diverse  
689 means (including flyers). This erroneous information could be due to the fact that those people have never  
690 experienced the situation at first hand and have never paid attention to such a detail (though it cannot really  
691 be called a detail). Another possible cause is the increasing complexity of the actors' systems (Becerra &



692 Peltier, 2011). This is particularly true in the case of crisis management not only in Paris as a metropolis,  
693 including in the context of a flooding, but also in France in general.

694 In response to this lack of knowledge, Becerra *et al.* (2013) suggest “personalizing the risk”. This idea  
695 has already been mooted by Thouret & D’Ercole (1996), who established that repeated personalized  
696 information which, moreover, is confirmed by many different formal sources, is necessary before the event  
697 happens. What information, however, can be personalized in tangible terms? Much information on the  
698 flood risk in the 15<sup>th</sup> district is already shared through meetings as well as in printed media and on Internet  
699 (<https://episcine.fr/>, [http://www.leparisien.fr/paris-75/83-300-habitants-du-xve-seraient-touchees-par-une-](http://www.leparisien.fr/paris-75/83-300-habitants-du-xve-seraient-touchees-par-une-crue-centennale-04-12-2016-6412278.php)  
700 [crue-centennale-04-12-2016-6412278.php](http://www.leparisien.fr/paris-75/83-300-habitants-du-xve-seraient-touchees-par-une-crue-centennale-04-12-2016-6412278.php)). The majority of this information is therefore already  
701 accessible. However, residents are not particularly well informed about the consequences in terms of the  
702 disruption to services inside their building. Anyway, the person who determines and shares such  
703 information should not create panic among the population while informing them about flood risk.

704 Another way to keep people informed is to encourage “intermediate actors” (Filâtre *et al.*, 2005) who  
705 would willingly receive, transfer and translate information in real time among different categories of actor  
706 (Becerra *et al.*, 2013). In the case of high-rise buildings, there are several possible intermediaries including  
707 the building manager, the “president of the tower”, or maybe a totally different person if needed. Anyway,  
708 when providing written answers, some residents already asked for the building manager to be appointed  
709 as the intermediate actor. This helps reinforce social participation and civic responsibility in flood  
710 prevention (Becerra *et al.*, 2013).

#### 711 4.4. Limitations and perspectives of a first-step study in a particular context

712 Ultimately, it should be recalled that in such a prospective study, there is always a gap between  
713 perceptions and behavior in a real context of flooding. Although the results revealed that only a few people  
714 would not evacuate, other people’s opinions should not be self-sufficient. It is certain that the better  
715 informed people are (notably with a clear, more specific warning), the more they react accordingly (Mileti  
716 & Beck, 1975). However, even being well informed does not entirely guarantee that the real action would  
717 be the same as the one mentioned in the completed questionnaire. Nevertheless, the descriptive statistics  
718 showed some particularly coherent answers, for example for T1 (totally autonomous), T2a (partially  
719 dependent regarding the relocation place and/or the means of transport to get there) or T3 (totally  
720 dependent).

721 Across all the results and analyses, one main limitation was observed: the survey was not sufficiently  
722 detailed to provide all relevant explanations. There is therefore a need for further analyses of the different  
723 factors which explain the perceptions of and reasons for evacuation such as personal experiences,  
724 knowledge and characteristics to name but a few. Moreover, the survey did not directly examine the  
725 reasons why people would not evacuate, according to their own perceptions. This could help in anticipating  
726 evacuation behavior. This idea of explaining the reasons not to evacuate is inspired by the works of other  
727 authors such as Baker (1991), Dow & Cutter (2000), Riad *et al.* (2006) and Kolen (2013).



728 Furthermore, this study could not explore all the particularities of the case of high-rise buildings. One  
729 such particularity is that living in a high-rise building could provide a certain feeling of security. This idea  
730 was implicitly evoked throughout our analyses but could not be formally confirmed as there were no direct  
731 questions on this matter. In fact, the perceptions of people living in smaller buildings differ from that.  
732 Many authors found that residents feel much more concerned when they are convinced that there is a risk  
733 of serious injury to themselves, their families or of damage to their homes (Baker, 1991; Gladwin *et al.*  
734 2001; Huang *et al.*, 2012; Riad *et al.*, 2006; Lindell *et al.*, 2005; Whitehead *et al.*, 2000). This means that  
735 when faced with the same hazard, in the 15<sup>th</sup> district of Paris for example, the residents of high-rise  
736 buildings and those of small buildings would not take the same decision concerning evacuation.

737 Finally, this paper highlighted a certain number of results that could inspire broader studies in  
738 geographical terms. This could be the level of knowledge in the event of evacuation (for example who  
739 does what or what the flood risk is in the area concerned? etc.) or the opinion on law n° 2004-811 (in a  
740 much larger survey, would opinions still be as mixed as they are in our case study? Why?). Even the  
741 proportion of people willing to evacuate or not and their evacuation capacities vary geographically. All  
742 these issues can be explored through further studies.

## 743 5. Conclusion

744 This paper addresses evacuation issues in the case of the Parisian metropolis following major flooding  
745 with slow kinetics. The central question concerns the proportion of people who are willing to evacuate, the  
746 constraints they face and their capacity to self-evacuate, self-host and reach a relocation place. The overall  
747 approach relies on a prospective study based on a survey conducted in a Parisian area on the banks of the  
748 River Seine, and more particularly in high-rise buildings.

749 The main typology results, those of a, revealed that the majority of the respondents would be partially  
750 dependent in the event of an evacuation. More precisely, one group among them is predominant: those  
751 who do not have a relocation place and/or private means of transport to get there. Ultimately, after  
752 comparing all the detailed results, the relocation process is the main issue of concern to the residents,  
753 especially the older ones. In total, four factors are shown to be important to people and could encourage  
754 them to evacuate: (1) the evacuation advice from the public authorities, (2) the fact that they know they  
755 have a relocation place and can get there, (3) the disruption of the facilities in their building, and (4) formal  
756 and clear information about the hazard and its consequences. The different actors have to better anticipate  
757 the evacuation behavior by taking these factors into account.

758 Furthermore, the matter of approval of law n° 2004-811 on the modernization of civil security was  
759 addressed in this paper. Our study provided certain explanations underpinning the reasons why this law is  
760 controversial. One possible way to make it more efficient is to run general and personalized information  
761 campaigns on the risk of flooding, its consequences and the adaptive reactions. The literature also  
762 emphasizes the aspect of risk perception. This study helped provide a global view of the trend in  
763 perceptions, but it is limited regarding explanations.



764           Anyway, this paper proposes another perspective in the field of flood risk and evacuation surveys: it  
765 is a study dealing with anticipation, while most studies focus on past experiences. In fact, the public  
766 authorities do not, at present, have information on people's capacity to self-evacuate, reach a relocation  
767 place or self-host. Are the residents of high-rise buildings prepared for evacuation? They are not that well  
768 prepared and this study provides details relating to this without waiting for a disaster to occur in order to  
769 learn from it. Another major contribution of this paper is the perspectives it offers on preparation for  
770 flooding, in particular with slow kinetics. This raises specific issues relating to information and the  
771 coordination of an evacuation as the actors and populations normally have time to prepare themselves for  
772 the crisis. Moreover, people might be dimly aware of the consequences of progressive flooding, which  
773 does not give rise to emergency evacuations. Finally, this study is a first step towards a possible broader  
774 geographical analysis of people's perceptions and capacities in order to better prepare themselves and the  
775 authorities for evacuation in moderate risk areas. To deepen this prospective research, the team of the  
776 RGC4 project also conducted a survey in ex-post situation in the suburbs of Paris that were flooded and  
777 affected during the 2016 and 2018 Seine floods and its tributaries. It will be particularly interesting to  
778 compare the results of these two recent surveys. Furthermore, other methods could complete this step,  
779 notably modelling. This might consist of predicting the proportion of people willing to evacuate and the  
780 timing of evacuation, a very essential estimate for decision support.  
781





782

783 **Appendix – Questionnaire sent to the residential high rise building households near the Seine**

Spring 2019

AGENCE NATIONALE DE LA RECHERCHE ANR

UNIVERSITE DE VERSAILLES ST-QUENTIN-EN-YVELINES

UNIVERSITE PARIS-SACLAY

EIVP

## ARE YOU PREPARED FOR THE EVACUATION OF THE FRONT DE SEINE TOWERS ?


### LARGE SCALE CITIZEN'S SURVEY

WHY? Because evacuation will be mandatory in case of a long time blackout subsequent, for instance, to an exceptional flooding of the Seine. The blackout will put the elevators out of service, and in your flat, everything that requires electricity will also stop working!

IT IS IMPORTANT THAT YOU FILL THIS SURVEY. It will be useful in providing information on your ability to leave your tower and join a safe place.

WE EXPECT YOUR RESPONSES in order to make recommendations to the municipal services, the emergency and crisis management services. The objective is to better inform and accompany you in such a situation.

THANK YOU FOR PARTICIPATING.



NAME OF THE PROJECT : "RGC4"  
Urban Resilience and Crisis Management in a context of Slow Kinetic Flood in Grand Paris, project lead : Engineers' School of the City of Paris, 80 rue Rebeval 75019 Paris. (<https://uriz.fr/9Eig>)

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PARTNER in charge of the survey and contact :  
Mme Nathalie Pottier, Teacher-Researcher [nathalie.pottier@uvsq.fr](mailto:nathalie.pottier@uvsq.fr)  
CEMOTEV Laboratory of the University of Versailles St-Quentin-en-Yvelines, 47 Bd Vauban 78047 Guyancourt

The Municipality of the 15th district, the City of Paris and the Paris Prefecture are aware of this survey.

Your area in the 15th district gathers the most numerous and tallest buildings in Paris, by the Seine riverside. This is why we have chosen it as our pilot survey with 14 towers.

The floodings in 2016 and 2018 in the Parisian region showed that the disturbances extended beyond the flooded area (transportation, degradation of the basic services).  
Let us get prepared altogether.

**THE REPONSES COLLECTED WILL BE ANONYMOUS**

Are you interested in the results?  
A synthesis of the results will be shared to the residents in autumn 2019.  
You can also express freely your opinions about the subject on a paper that you will attach to this questionnaire.

#### HOW TO GIVE THIS QUESTIONNAIRE BACK?

Thank you for putting the questionnaire in a closed envelop and dropping it into the drop box on the reception desk of the tower.

Thank you for replying **AS SOON AS POSSIBLE**, by June 15th, 2019. (in case you were away, we can accept belated filled questionnaire that you will leave at the reception desk or by mailing to the partner's address but the sooner, the better!)

784





1. What is the name of your tower? \_\_\_\_\_

2. Which floor is your flat on? \_\_\_\_\_

3. When did you move in this tower (date or year)? \_\_\_\_\_

4. Have you got any pet(s)?

No  Yes, but they are hard to transport or are cumbersome in case of evacuation

Yes, and they are easy to transport in case of evacuation  Other. Specify whether they need special precautions in case of transportation (animal in a cage or dangerous...): \_\_\_\_\_

5. Do you know what to do in case of an evacuation advisory?

Yes  Partly  No

6. If you have got a vehicle, on which level is it parked?

Parking -2 under slab  Parking -1 under slab  Underground parking elsewhere  On surface

7. If you receive an advisory to evacuate the underground parkings due to a flood, WITHOUT any other advisory to evacuate the towers, what will you do?

	I move my car away and...	I haven't got a car
I stay home and better assess how hazardous the situation is	<input type="checkbox"/>	<input type="checkbox"/>
I prepare myself to leave home within 24h	<input type="checkbox"/>	<input type="checkbox"/>
I take this opportunity to leave immediately	<input type="checkbox"/>	<input type="checkbox"/>
I do not know what decision I would make	<input type="checkbox"/>	<input type="checkbox"/>

8. What do you think of the following statements?

	TRUE	FALSE	DO NOT KNOW
This area has never been flooded	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
An exceptional flooding of the Seine in Paris is predictable at least one week before	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Thanks to all of the infrastructures (dams, murettes, etc.), this area cannot get flooded at all	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The tower has power generators that guarantee electricity autonomy for at least 4 or 5 days	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
In case of blackout in the tower, I can conserve tap water and waste water evacuation system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
The public authorities are able to host and/or rehouse all of the residents of the towers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



9. Except for fragile people, the modernisation law of the Civil Security recommends the self-evacuation and self-hosting BUT NOT JUST EXPECTING the help from public authorities. Do you agree?

I totally agree       I totally disagree  
 I would rather agree       No opinion  
 I do not really agree      Specify your opinion: \_\_\_\_\_

10. If the prefecture issue an evacuation advisory linked with a major flood of the Seine, do you think they might ask you to evacuate:

Long before water invades your area (from 24 to 48h)  
 Only when the water has reached the cellar and/or the streets in this area  
 Only if the flood in this area lasts too long (several days)

11. If you had to leave this tower for several weeks due to a major flooding of the Seine, what would incite you to make that decision? (Many possible options)

a) Nothing, I will not leave my home in any case  
 b) The preventive evacuation advisories from the public authorities and the emergency services (24-48h before this area gets flooded)  
 c) The departure of at least half of my neighbours in my building  
 d) The departure of at least half of next-door neighbours  
 e) The information from the media or my surroundings about the degradation of the situation  
 f) Knowing that if I do not leave on time, I could not count anymore on the emergency services afterwards  
 g) Knowing that my apartment will be in a secure area  
 h) The deterioration of living conditions (at my place and/or in this area)  
 i) Knowing where I could be hosted and being able to join that place  
 j) Other reason (to be specified): \_\_\_\_\_

12. Among these reasons above (from b to j), which are the 3 first reasons which would incite you to leave?

1st:       2nd:       3rd:

13. If you are given 24 to 48h to organise your evacuation before the disturbance of the transportations, where would you go? (this detail is critical for the mobility plan outside the disaster area)

I have got one or many possible places to go  
Specify your eventual host city(/ies) or place(s):  
\_\_\_\_\_  
\_\_\_\_\_

I have no place to go, it will depend on the housing provided by the authorities  
 I do not know if I would leave within such a time limit

14. How would you leave?

By public transport       I count on the means of transport from the public authorities, the solidarity...  
 By car       I do not know  
 My relatives or friends, who will host me, would probably come and take me by car       Other (to be specified): \_\_\_\_\_



15. As regards to working people, do you think you would be able to continue working from where you would be hosted?

Yes, if means of transport are available       No  
 Yes, by teleworking       I do not know

16. Put these inconveniences in order which would make you leave if they lasted more than 3 days:

1st:     2nd:     3rd:     4th:     5th:     6th:     7th:

a) No more elevator      e) No more help from the emergency services  
b) No more drinking water      f) No more public transports  
c) No more toilets (backup of wastewater)      g) Other (to be specified): \_\_\_\_\_  
d) No more food supplies

17. What would you wish to be done so that you will be better prepared in case you need to leave?

18. What pieces of information would be useful to you in order to leave on time in case of a generalised flooding?

*And last*

19. The respondent is:

A woman       A man

20. The respondent's age range :

Less than 25 years old       Between 45 and 65 years old  
 Between 25 and 45 years old       More than 65 years old

21. Number of people in your home: \_\_\_\_\_

22. Particularity of people in your home to be taken into account in case of evacuation:

None       Less than 15 year old child(ren)  
 Disabled people       Elderly people  
 At least one person in your home needs a regular medical or external assistance       Another particularity: \_\_\_\_\_

23. Status of the respondent:

Active       Inactive (domestic work , looking for a job)  
 Retired

YOU CAN EXPRESS FREELY ON ANOTHER PIECE OF PAPER YOUR OPINIONS, NEEDS OR IDEAS ABOUT "EVACUATION-FLOODING-INFORMATION-HOSTING" OR ABOUT THE SURVEY METHOD. **THANK YOU**

The data will be strictly archived in an anonymous way in a computer in view to a statistical treatment and synthesis by the IGCE project researchers. You will get the access to that synthesis (an information about the dissemination methods will be displayed through billboards in the halls).

787

788



789 *Authors contributions.* This work was carried out by NR as part of her post-doctorate under the direction  
790 of NP. She disseminated and collected the survey data with the support of NP and the help of AMES on  
791 more technical points. The first writing and methodology for processing survey data were done by NR.  
792 AMES, MV and NP contributed to the concept and writing, and helped with revisions as well as  
793 proofreading.

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806

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